

A NEW LOWER ORDOVICIAN GRAPTOLITE FAUNA FROM THE TRONDHEIM REGION

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Abstract. A graptolitic shale has been found within the Hovin succession near Løkken in the Trondheim Region, and several new fossil localities have been discovered. This shale is called the Bogo Shale. The graptolite fauna, which is described, includes a new subspecies, *Dichograptus octobrachiatus minimus* n. subsp., and some forms not previously recorded in Norway. From its fauna, the shale is considered to be of Lower Ordovician age, equivalent to the 3by zone of the Oslo Region.

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Introduction

During the summer of 1960 the author carried out six weeks geological mapping in an area some 70 km. S.W. of Trondheim, between Løkken in the west and the Hølonda-Horg District (mapped by T. VOGT, 1945) in the east. In the area mapped there is a westward-pointing V-shaped outcrop of sedimentary rocks belonging to the Hovin Series, which is fault-bounded to the north and south by the older Støren Series. Within the Hovin sediments a graptolitic shale with

an abundant fauna was found, and several new fossil localities were discovered.

Besides the graptolitic shale, here called the Bogo Shale, after the type localities along the river Bogo, the Hovin Series includes conglomerates, grits, sandstones, grey shales, sandy shales, and limestones. The beds all dip northwards at angles of 45° or more, and graded bedding shows that all the strata are inverted. These sediments have been intruded by elongate bodies of "porphyrite" roughly parallel to the general strike. Later faulting has resulted in variable displacements of beds, with frequent changes of rock type along the strike.

The Bogo Shale, which is some 60 m. thick, lies sandwiched between two conglomeratic beds near the base of the Hovin succession. Its exact position in relationship to the Venna or Stokkvola Conglomerate, which occurs at the base of the Hovin Series, is not certain. The shale is variably pyritous, dark grey to blue grey, and possesses a good shaly parting; weathered surfaces usually have a rusty appearance due to the pyrite content. Fossils have a sporadic distribution, being very common in certain bands at some localities whilst in others they are very rare or absent. Graptolites are the most common fossils, though fragments of phyllocarid crustacea are abundant in some layers; a single hyolithid specimen and some poorly preserved brachiopods of *Obolus* type have also been found. Along the river Bogo to the north of the Bogo Shale a dark grey pyritous "slate" outcrops, separated from the graptolitic shale by a greenish conglomeratic feldspathic grit, 50 m. thick. No fossils were found in this "slate", though it may possibly be a more metamorphosed equivalent of the Bogo Shale repeated by strike faulting.

The drawings of graptolites accompanying this paper were made using a Parkes-Lapworth Microscope of the type used in the preparation of the Monograph of British Graptolites by ELLIS and WOOD (1901—1918). These drawings have been reduced photographically to their present scale. The photographs were made under the direction of Mr. J. A. GEE, of Imperial College London, and are unretouched.

The types are deposited in the Paleontologisk Museum, Oslo.

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encouragement; also Dr. Gwyn Thomas for reading the manuscript, and Mr. Brian Chadwick for much useful discussion.

Description of localities

The exposures of the Bogo Shale along and to the west of the river Bogo are shown in fig. 1. Only at localities 1, 2 and 3 have identifiable fossils been found, though localities 5 and 7 have each yielded a single distorted graptolite. The other exposures shown consist of similar though apparently unfossiliferous shales.

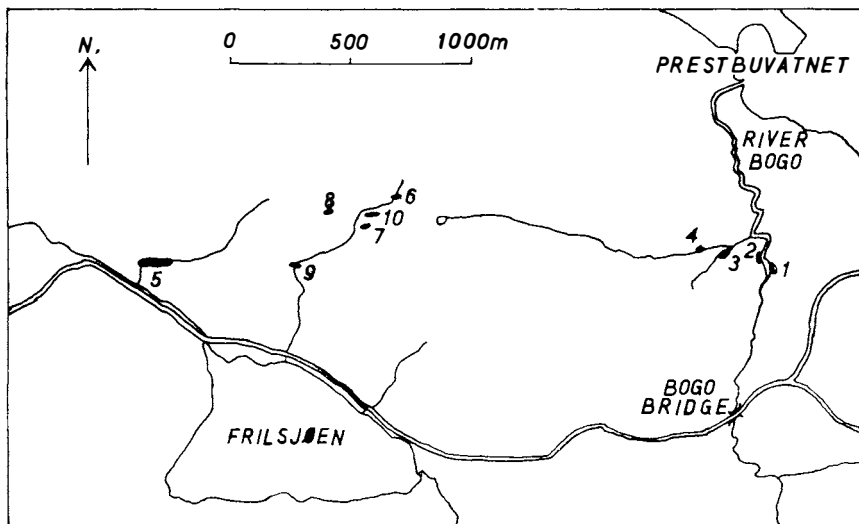


Fig. 1. Sketch map showing the locations of the Bogo Shale exposures.

Locality 1 is on the east bank of the river Bogo, where it widens out below a series of rapids 800 m. upstream from its outlet into Prestbuvatnet. The shale is exposed in a low cliff which is separated from the conglomeratic grit forming the rapids by a grass bank 10 m. wide. The shale dips northwards at 65° , and is presumably inverted. A vertical strike fault which crosses the outcrop is downthrown to the south, and has resulted in the repetition of the part of the shale succession. The youngest beds exposed are two dark blue gritty limestone bands, each 12 cm. thick, separated by a very thin black shaly layer. To the north occur 4 m. of dark grey slightly pyritous shale,

with occasional thin grey silty and gritty bands. Certain layers contain a prolific fauna, largely of graptolites preserved as pyritous or carbonaceous impressions and often in part relief. The following fossils have been found here: *Dichograptus octobrachiatus minimus* n. subsp., *Trichograptus* cf. *fergusoni*, *Didymograptus extensus*, *D.* cf. *leptograptoides*, *D.* cf. *filiiformis*, *Didymograptus* sp., *Isograptus caduceus* var. *divergens*, *Isograptus caduceus* var. *velata*, *Tetragraptus quadribachiatus*, *T. bigsbyi*, *Tetragraptus* sp., *Phyllograptus anna*, *Hallograptus inutilis*, *Glossograptus hincksi*, *G. hincksi* var. *fimbriatus*, *Glyptograptus dentatus*, phyllocarid fragments, inarticulate brachiopods and a hyolithid.

Locality 2 is a further 40 m. downstream, on the west bank of the river Bogo. Here the river has cut through a low ridge, forming a bluff 6 m. high. The exposed shale is 7 m. thick and is bounded to the north by a strike-fault zone, 2 m. wide, with a greenish conglomeratic grit on the northern side. The shale at this exposure is rather softer and less pyritous than at the previous locality, and is characterised by certain layers having paper-thin cleavages, with graptolites preserved as carbonaceous films. The following fossils have been found here: *Didymograptus extensus*, *Isograptus caduceus* var. *divergens*, *I. caduceus* var. *velata*, *Glossograptus hincksi*, *Glyptograptus dentatus*, and phyllocarid fragments.

The other main fossiliferous exposure, locality 3, lies 150 m. to the west of the river Bogo, isolated in the bed of a small tributary stream. As at locality 1 the shales lie to the north of a thin dark blue gritty limestone band, and the shales have the same general character, without the paper-thin cleavage characteristic of locality 2. Fossils were found in only two bands, and the following have been identified: *Dichograptus octobrachiatus minimus* n. subsp., *Didymograptus extensus*, *D. nitidus*, *Isograptus caduceus* var. *divergens* and var. *velata*, *Phyllograptus anna*, *Glyptograptus dentatus*, and inarticulate brachiopods. Just to the north-west is a similar exposure in a stream bed (locality 4), but no fossils were found here.

In the exposures of similar shale further west graptolites are very rare and other fossils apparently absent. At locality 6 a dark grey pyritous shale is exposed in a stream bed in contact with a greenish feldspathic grit to the south. A similar exposure is seen at locality 5, where a stream flows to the south of and parallel to an east-west fault scarp formed of tuffaceous conglomerate; here a badly distorted

diplograptid graptolite was found. Locality 9 is another stream exposure, while to the east, at localities 7, 8 and 10, situated on either side of a low ridge, the shale is seen in contact with an intrusive doleritic body; another diplograptid, again badly distorted, was found at locality 7.

An exposure on the Trivja River, just to the south of Storbuvatnet, shows a dark grey carbonaceous shale in contact with the porphyry intrusion which partly forms the Granin Ridge. Some graptolite fragments, preserved as carbonaceous films, were discovered, but are too poorly preserved for identification.

Description of species

CLASS: GRAPTOLITHINA BRONN, 1846

ORDER: GRAPTOLOIDEA LAPWORTH, 1875

FAMILY: DICHOGRAPTIDAE LAPWORTH, 1873

Genus: *Dichograptus* SALTER, 1863

Dichograptus octobrachiatus (HALL, 1858) *minus* n. subsp.

Plate 1, fig. 1. Plate 2, fig. 1.

HOLOTYPE: P.M.O. no. 72815, (pl. 1, fig. 1; pl. 2, fig. 1) from locality 1 at the river Bogo, Trondheim Region.

DIAGNOSIS: Differs from *Dichograptus octobrachiatus* (J. HALL, 1858) in having more slender stipes, a greater number (6–7) of thecae in 5 mm, and thecae with straight or weakly concave ventral margins.

DESCRIPTION: Rhabdosome consists of straight and rigid stipes of three orders. The two first order stipes which form the "funicle", 2.0–2.7 mm. long, divide dichotomously to form four second order stipes 0.8–1.5 mm. in length; these in turn divide dichotomously to form a total of eight third order stipes up to 8 mm. in length and 0.25–0.5 mm. in width: the first and second order stipes have a constant width of 0.25 mm. Thecae are generally poorly preserved, 6–7 in 5 mm., overlapping for $\frac{1}{2}$ to $\frac{1}{3}$ their length and inclined to the axis at 20°–40°; their ventral margins are straight or weakly concave.

REMARKS: Though rather indifferently preserved all the specimens found have the same constant character which serves to distinguish them from other forms of *Dichograptus*. They differ from the typical *D. octobrachiatus* (J. HALL) in the much more slender stipes and the

greater number of thecae per unit length, as well as a different thecal shape. In these respects they appear more similar to *D. seperatus*, ELLES and WOOD, from which they differ in the length of the funicle (6 mm. long in *D. seperatus*). TURNER (1960) has described a similar form with a funicle not longer than 3 mm., as *D. seperatus*, from the Upper Arenigian of Guandacol, Argentina. Forms of *D. octobrachiatus* are known from the *D. balticus* to *P. densus* zones of Norway, while in Britain the species occurs throughout the *Dichograptus* and *Didymograptus extensus* zones.

ASSOCIATIONS: Found at localities 1 and 3, with *Didymograptus extensus*, *D. cf. filiformis*, *Tetragraptus quadribrahiabus*, *Tetragraptus* sp., *Isograptus caduceus* var. *divergens*, *Glossograptus hincksi*, and *Glyptograptus dentatus*.

Genus: *Trichograptus* NICHOLSON, 1876

Trichograptus cf. *fergusoni* HALL, 1912

Plate 1, figs. 2, 3; Plate 2, fig. 2.

DESCRIPTION: Rhabdosome consists of two first order stipes, 1.2 cm long, initially diverging from the sicula at 120°, though becoming bent towards 180° distally; each stipe gives off up to four second order stipes from the same side. The sicula is imperfectly preserved, greater than 0.5 mm in length but only 0.1 mm. wide. The second order stipes, up to 1.5 cm long, with a maximum width of 0.7 mm., are given off at single theca intervals, apparently from the thecal apertures on the first order stipes. The thecae, 7–8 in 10 mm., are 1.5 mm. long and 3–4 times as long as wide; they have an overlap of ½ to ¼ their length and an inclination to the axis of 15°–25°; ventral margins are straight or weakly concave whilst the apertural margins are straight with a variable inclination to the axis.

REMARKS: The nature of the stipes and the disposition of the thecae are similar to that of *Trichograptus fergusoni* HALL redescribed by HARRIS and THOMAS (1938a) from Victoria, Australia, though the inclination of the thecae and the initial divergence of stipes are rather greater in the specimens from the river Bogo. In *Trichograptus dilaceratus* HERMANN, the thecae are more numerous per unit length. The species *T. fergusoni* is recorded from the Arenigian of Victoria.

ASSOCIATIONS: The only two specimens found (at locality 1) were

associated with *Didymograptus extensus*, *Glyptograptus dentatus*, *Glossograptus* sp., crustacea and inarticulate brachiopods of *Obolus* type.

Genus: *Didymograptus* MCCOY, 1851

Didymograptus extensus (HALL, 1858)

Plate 1, fig. 10; Plate 2, figs. 10, 11.

DESCRIPTION: Sicula rather small and inconspicuous, from 1.0—1.2 mm. long. Slender, slightly flexuous stipes of apical origin, horizontal, generally diverging at 180°, though initial angles between 180° and 160° are recorded: they vary in length from 4 mm. to more than 8 cm., with an initial width of 0.5—0.7 mm. gradually increasing distally to 1.4 mm. (1.8 mm. in the case of one specimen). Thecae 10—11 in 10 mm. proximally, 9—10 distally, increasing in length away from the sicula from 1.5 mm. to 3 mm., with an overlap increasing similarly from 1/2 to 2/3; they are inclined to the stipe axis at angles varying from 20°—40°, the higher angles being more typical, especially towards the distal extremities; their ventral margins are straight or weakly concave, as are the apertural angles, the latter being normal or nearly so to the thecal axes.

REMARKS: The majority of the specimens fall within the limits of this species as defined by ELLES and WOOD (1901) and by RUEDEMANN (1947). The slightly greater number of thecae per unit length in some cases, and the occasional initial divergence angle of less than 180° are presumably minor local variations. No specimens were found of the two varieties *elatus* and *linearis* described by MONSEN (1937). This restricted species has previously been recorded by LAPWORTH (1905) from the Trondheim region. In Britain it occurs throughout the *Didymograptus extensus* zone and survives in small numbers into the basal part of the *D. hirundo* zone. MONSEN recorded her two varieties of the species from the *Phyllograptus densus* zone of Southern Norway.

ASSOCIATIONS: The species occurs quite commonly at localities 1, 2, 3, where it is associated with *Didymograptus nitidus*, *D. cf. leptograptoides*, *D. cf. filiformis*, *Dichograptus octobrachiatus minimus* n. subsp., *Trichograptus cf. fergusonii*, *Isograptus caduceus* var. *divergens*, *I. caduceus* var. *velata*, *Tetragraptus quadribrachiatus*, *T. bigsbyi*, *Glyptograptus dentatus*, *Glossograptus hincksi*, *Hallograptus inutilis*, crustacean fragments and inarticulate brachiopods.

Didymograptus cf. *leptograptoides* MONSEN, 1937

Plate 2, fig. 12.

DESCRIPTION: Stipe fragments only, up to 5 cm. long and 0.4–0.5 mm. wide, flexuous. Thecae 10 in 10 mm., of average length 2.0 mm. about 8 times as long as wide and inclined to the axis at around 15°; ventral margins have a distinct sigmoidal curvature; apertural margins form angles of less than 90° with the thecal axes.

REMARKS: Though the sicula is not seen in the specimens collected, the long slender flexuous stipes and the shape of the thecae suggest close affinities with MONSEN's species. However, the specimens from the Bogo shale do not show the undulation of the dorsal margin of the stipes, which is a characteristic of the species. In Norway the species occurs in the *P. densus* and *P. augustifolius* var. *elongatus* zones (MONSEN 1937) and in the *D. gracilis*-*P. densus* zones of Sweden (Tjernvik 1960). It has also been recorded in South America (TURNER 1960) from the Lower Llanvirnian, where it is associated with *Phyllograptus augustifolius* var. *elongatus*.

ASSOCIATIONS: The species was only found within a thin layer at the northern end of locality 1, and occurs with *Didymograptus extensus*, *Isograptus caduceus* var. *divergens*, and *Glyptograptus dentatus*.

Didymograptus cf. *filiiformis* TULLBERG, 1880

DESCRIPTION: Stipes arise at different heights from a thin sicula 0.7 mm. long; they diverge at between 90° and 100°, are short (less than 12 mm. long) and have a uniform width of 0.25 mm. Thecae are narrow tubes, about 4 in 5 mm., with little or no overlap; apertural and ventral margins are straight, the former being normal to the stipe axis.

REMARKS: This form is similar to that described by BULMAN (1950) from Sweden, in having a slightly greater number of thecae per unit length than in TULLBERG's type species. MONSEN (1937) has recorded *D. filiiformis* from the *Didymograptus validus* to *Phyllograptus densus* zones in Norway, while in Sweden it is known from the *D. balticus* zone (TJERNVIK 1960).

ASSOCIATIONS: Two specimens were found at locality 1, rather indifferently preserved, with *D. extensus*, *Dichograptus octobrachiatus minimus* n. subsp., *Isograptus caduceus* var. *divergens*, and *Glossograptus hincksi*.

Didymograptus nitidus (HALL, 1857)

REMARKS: A single stipe fragment, 1.5 cm. long and 1.2 mm. wide, with 14 thecae in 10 mm., which was found at locality 3, associated with *Didymograptus extensus*, may belong to this species.

Didymograptus sp.

REMARKS: At locality 1, numerous very slender stipe fragments, up to 1.5 cm. long, occur, some of which show the presence of possible siculae. The stipes have a maximum width of 0.2 mm. and they apparently diverge at 180° from a small insignificant sicula. The thecae are narrow tubes, 1 mm. long and about six times as long as wide, with no overlap and very low angles of inclination. They are associated with *Dichograptus octobrachiatus minimus* n. subsp., *Tetragraptus* sp., and *Glossograptus hincksi*.

Genus: *Isograptus* MOBERG, 1892

Isograptus caduceus (SALTER, 1853) var. *divergens* HARRIS, 1933

Plate 1, figs. 8, 9; Plate 2, figs. 7, 8.

DESCRIPTION: Rhabdosome reclined, with the two stipes diverging at angles between 315 and 335°. The stipes, in some cases more than 5 cm. long, are 1.5 to 2.0 mm. wide proximally; they usually widen gradually to a maximum of 2.5 mm. (excluding apertural spines) before decreasing slightly towards the distal extremities. The sicula is prominent, 3.0–4.0 mm. long, with a maximum width approaching 1 mm., a narrow nema, often more than 5 mm. long, is characteristically present. Thecae number 10–12 in 10 mm. proximally; 9–10 distally, varying in length from 2 mm. proximally to 6 mm. distally: they are three to eight times as long as wide and are in contact for all or almost all of their length: ventral margins are concave, while the apertural margins are straight or weakly concave and nearly parallel to the stipe axes: the thecae possess downward-pointing apertural spines, about 0.5 mm. long.

REMARKS: The specimens are much larger than other European isograptids and are similar to the large forms found in Australia and North and South America. They appear identical to *Isograptus caduceus* var. *divergens*, described by HARRIS (1933) from the upper Arenigian (Yapeenian) of Australia; this variety has also been described by

BULMAN (1931) from the Llanvirnian of Bolivia. In Argentina TURNER (1960) has described under *Isograptus gibberulus* four varieties of which his variety *a*, from the Upper Arenigian of Guandacol is most similar to *I. caduceus* var. *divergens*. In Norway no isograptids are known from below the *P. densus* zone, while in Britain the genus first appears in the *nitidus* sub-zone of the *D. extensus* zone. The variety *divergens* is considered by HARRIS and KEBLE (1932) to be one of the latest varieties of *I. caduceus*, though it is one of the earliest varieties known in Argentina and also, apparently in Norway.

ASSOCIATIONS: It is quite common at localities 1, 2 and 3, where it is associated with *I. caduceus* var. *velata*, *Didymograptus extensus*, *D. cf. filiformis*, *D. cf. leptograptoides*, *Dichograptus octobrachiatus minimus* n. subsp., *Tetragraptus quadribachiatus*, *Glossograptus hincksi*, *Glyptograptus dentatus*, and *Phyllograptus anna*.

Isograptus caduceus (SALTER), var. *velata* HARRIS, 1933.

Plate 1, figs. 4–7; Plate 2, fig. 3.

DESCRIPTION: Rhabdosome small, semi-circular, with a maximum length and breadth of 5 mm. The sicula is fusiform, 2–2.5 mm. long, with a maximum width of 0.6 mm.: a virgula up to 5 mm. long is typically present. The thecae appear to grow outwards from near the base of the sicula, the later thecae turning outwards to form the two stipes which enclose the sicular region, and in a few cases, extend a short distance beyond it. Thecae, 4 in 2.5 mm., overlapping almost completely near the origin though this decreases slightly distally; ventral margins weakly concave; apertural margins concave, with short thecal spines.

REMARKS: These forms are very similar to *I. dumosus* (HARRIS 1933) from which they can be distinguished by the absence of a "tuft" of thecae below the sicula, and the presence of the typical *I. caduceus* thecae and sicula shape, showing that they belong to the *velata* variety of *I. caduceus*. In Australia this variety occurs at the same level as *I. caduceus* var. *divergens*, while a similar form, from the Upper Arenigian of Guandacol, Argentina, which is described by TURNER (1960) as *I. gibberulus* var. *a* is associated with his *I. gibberulus* var. *a*.

ASSOCIATIONS: It occurs at localities 1, 2 and 3, associated with *I. caduceus* var. *divergens*, *Didymograptus extensus*, *Tetragraptus* sp., *Glyptograptus dentatus*, *Glossograptus hincksi*, and *Phyllograptus anna*.

Genus: *Tetragraptus* SALTER, 1863

The following types were found at locality 1:

Tetragraptus quadribrahiatus (HALL, 1859) — Plate 2, fig. 4.

A few specimens.

Tetragraptus bigsbyi (HALL, 1865) — Plate 1, fig. 11.

Two specimens.

Tetragraptus sp.

Several specimens too poorly preserved for specific identification.

ASSOCIATIONS: The *Tetragraptus* specimens were associated with *Dichograptus octobrahiatus minimus* n. subsp., *Didymograptus extensus*, *Didymograptus* sp., *Isograptus caduceus* var. *divergens*, *Glossograptus hincksi*, and *Glyptograptus dentatus*.

Genus: *Phyllograptus* HALL, 1858

Phyllograptus anna HALL, 1865

Plate 2, fig. 5.

REMARKS: Two small specimens, 4.8 mm. long and 2.8 mm. in maximum width, were found at localities 1 and 3, associated with *Isograptus caduceus* var. *divergens*, *I. caduceus* var. *velata*, *Glossograptus hincksi*, and *G. hincksi*, var. *fimbriatus*.

FAMILY: DIPLOGRAPTIDAE LAPWORTH, 1873

Genus: *Glyptograptus* LAPWORTH, 1873

Glyptograptus dentatus (BRONGNIART, 1828)

Plate 1, figs 14, 15; Plate 2, figs. 2, 6.

DESCRIPTION: Rhabdosome generally narrow, of nearly constant width, with specimens up to 2 cm. long and from 1.2 to 2.0 mm. wide; they possess a squarish proximal end, often with a short virgella, whilst distally a nema, up to 1.6 cm. long, is usually present. Thecae 11–15 proximally, 10–12 distally, in 10 mm., free for half to one-third their length; rather variable in shape, commonly with a sigmoidal ventral wall and a slightly introverted apertural region; spines can frequently be seen on proximal thecae.

REMARKS: This is a very common form. All specimens fall within the limits of the species as set by RUEDEMANN (1904 and 1947), though a few fall outside the stricter limits set by ELLES and WOOD (1908). SPJELDØES (1953) has described *G. aff. dentatus* from the *P. augusti-*

folius var. *elongatus* and *D. hirundo* zones, this being the earliest recorded occurrence of *Glyptograptus* in Norway. In Britain, however, *Glyptograptus* is known rather earlier, *G. dentatus* first appearing in the Middle Arenigian (*D. nitidus* sub-zone).

ASSOCIATIONS: It occurs at localities 1, 2 and 3, associated with *Dichograptus octobrachiatus minimus* n. subsp., *Trichograptus* cf. *fergusoni*, *Didymograptus extensus*, *D.* cf. *leptograptoides*, *Isograptus caduceus* var. *divergens*, *Isograptus caduceus* var. *velata*, *Hallograptus inutilis*, and *Glossograptus hincksi*.

FAMILY: LASIOGRAPTIDAE LAPWORTH, 1880

Genus: *Hallograptus* LAPWORTH, 1877

Hallograptus inutilis (HALL, 1865)

Plate 2, fig. 13.

DESCRIPTION: Rhabdosome of moderate size, greatest length 7 mm. with a uniform width of 1.7 mm. Sicula not seen, short virgella present in some specimens. Thecae alternate, 7 in 5mm., inclined at 20°–30° and with an apparent overlap of 50%; ventral margins usually with slight sigmoidal curvature, becoming bent outwards towards the aperture; apertural margins straight or slightly convex, nearly normal to the axis, with a short stiff apertural spine. No lacinia seen.

REMARKS: The specimens are somewhat shorter in length than those of *Hallograptus* aff. *mucronatus inutilis* described by SPJELDNÆS (1953) from the *Didymograptus hirundo* zone of south Norway. In Britain *H. inutilis* has been recorded from the *D. extensus* and *D. nitidus* zones.

ASSOCIATIONS: Numerous specimens occur on a single bedding plane at locality 1, associated with *Glossograptus* sp., *Glyptograptus dentatus*, *Didymograptus extensus*, *Isograptus caduceus* var. *divergens*, *Tetragraptus* sp., and crustacean fragments.

FAMILY: CRYPTOGRAPTIDAE HADDING, 1915

Genus: *Glossograptus* EMMONS, 1855

Glossograptus hincksi (HOPKINSON, 1872)

Plate 1, fig. 12; Plate 2, fig. 9.

DESCRIPTION: Rhabdosome up to 2 cm. long and 3.5 mm. wide on lateral faces, excluding thecae spines 1.5 mm. long; generally parallel-

sided, with a rounded spinose proximal end and a prominent virgula up to 3.5 cm. in length distally. Thecae 10 to 14 in 10 mm.

REMARKS: The earliest glossograptids in Norway are recorded from the *P. augustifolius* var. *elongatus* zone (MONSEN 1937). They first appear at a similar horizon in Britain, where the earliest form is *G. acanthus*. In Britain *G. ciliatus* first appears in the Llandeilian of the Lake District.

ASSOCIATIONS: It occurs at localities 1 and 2 with *Glyptograptus dentatus*, *Dichograptus octobrachiatus minimus* n. subsp. *Didymograptus extensus*, *Isograptus caduceus* var. *divergens*, *Isograptus caduceus* var. *velata*, *Tetragraptus* sp., and *Glossograptus hincksi* var. *fimbriatus*.

Glossograptus hincksi (HOPKINSON) var. *fimbriatus* (HOPKINSON 1872)

Plate 1, fig. 13.

DESCRIPTION: Rhabdosome parallel-sided, 7 mm. long and 2.0–2.2 mm. wide, excluding slender thecal spines up to 1.5 mm. long; details of proximal end obscure; distally there is a prominent virgula 1.1 cm. long. Thecae number 7–8 in 5 mm., further details not seen.

REMARKS: This variety can be distinguished from *G. hincksi* by its much smaller size and more delicate thecal spines. It appears similar to *G. hincksi* var. *fimbriatus* described by ELLES and WOOD (1908) from the Arenigian and Llandeilian of Southern Scotland.

ASSOCIATIONS: Two specimens were found at locality 1, associated with *Glossograptus hincksi*, *Didymograptus* sp., *Isograptus caduceus* var. *divergens* *I. caduceus* var. *velata*, and *Phyllograptus anna*.

Stratigraphical considerations

The dating of the Bogo Shale is of considerable importance. Many of the graptolites found can be matched with those described by MONSEN (1937) and SPJELDNÆS (1953) from the Lower *Didymograptus* Shale of the Oslo Region. *Dichograptus octobrachiatus* subsp., *Didymograptus extensus*, *D. leptograptoides*, *D. filiformis*, *Isograptus caduceus* (varieties), *Tetragraptus quadribachiatus*, *T. bigsbyi* and *Phyllograptus anna*, all from the Bogo Shale, are only recorded together by MONSEN from within the *Phyllograptus densus* zone (3by), and it seems most likely

that the Bogo Shale itself occurs within this zone. This means that the Bogo Shale contains the earliest biserial graptolites so far recorded from Norway. In Britain *Glyptograptus dentatus* first appears at about this level as also does *Halograptus inutilis* and *Glossograptus hincksi* var. *fimbriatus*, though *Glossograptus hincksi* itself is not known from before the Llanvirnian. The varieties *divergens* and *velata* of *Isograptus caduceus* have only previously been recorded from Australia and South America, where HARRIS and KEBLE (1933) considered them to be late varieties of the *Isograptus caduceus* group, yet in Norway they are among the earliest isograptids known, occurring in the same zone as the smaller *Isograptus caduceus* var. *norvegicus* (MONSEN 1937) and apparently earlier than *Isograptus gibberulus*.

Previously the oldest dateable fossils from the Hovin Series have come from the Hølonde Limestone, which was considered by TH. VOGT (1945) to be of Upper Llanvirnian-Lower Llandeilian age, though T. STRAND (1947) has suggested a slightly later date (Llandeilian). Though this limestone must be younger than the Bogo Shale, its exact position in relation to the Bogo Shale, and of the Bogo Shale to the basal conglomerate of the Hovin Series, is not certain. The present paper suggests that there must have been a considerable time interval between the deposition of the shale and that of the limestone, and that the oldest Hovin sediments are at least as old as Middle Arenigian (*Phyllograptus densus* zone). In areas to the north, around Høydalen and Mjøvatnet, and to the east, around Hølonde, the Hovin sediments are seen to overlie the Støren Greenstones, with a basal conglomerate containing many greenstone and jasper boulders, and it seems likely that the greenstones of the Støren Series are at least as old as early Arenigian and are quite possible Tremadocian, a rather earlier date than has previously been suggested (VOGT 1945 and others).

LIST OF FOSSILS FROM THE BOGO SHALE.

	Localities:
<i>Dichograptus octobrachiatus</i> (Hall, 1858) <i>minimus</i> n. subsp.	1,3
<i>Trichograptus</i> cf. <i>fergusoni</i> Hall, 1912	1
<i>Didymograptus extensus</i> (Hall, 1858)	1,2,3
—»— cf. <i>leptograptoides</i> Mosen, 1937	1
—»— cf. <i>filiiformis</i> Tullberg, 1880	1
—»— <i>nitidus</i> (Hall, 1857)?	3
—»— sp.	1

<i>Isograptus caduceus</i> (Salter, 1853) var. <i>divergens</i> Harris, 1933	1,2,3
—»— —»— —»— var. <i>velata</i> Harris, 1933	1,2
<i>Tetragraptus quadribrachiatus</i> (Hall, 1858)	1
—»— <i>biggsbyi</i> (Hall, 1865)	1
—»— sp.	1
<i>Phyllograptus anna</i> Hall, 1865.	1,3
<i>Hallograptus inutilis</i> (Hall, 1865)	1
<i>Glossograptus hincksi</i> (Hopkinson, 1872)	1,2
—»— —»— var. <i>fimbriatus</i> (Hopkinson, 1872)	1
<i>Glyptograptus dentatus</i> (Brongniart, 1828)	1,2,3
Phyllocarid fragments	1,2
Inarticulate brachiopods	1,3
Hyolithid	1

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PLATES 1—2

PLATE I

The specimens are from the Bogo Shale at the river Bogo in the Trondheim Region. They are deposited in the Paleontologisk Museum, Oslo, and the numbers given are their catalogue numbers.

- Fig. 1: *Dichograptus octobrachiatus* (Hall, 1858) *minimus* n. subsp. p. 227
 Holotype (No. 72815). Locality 1. x 3
- Figs. 2—3: *Trichograptus* cf. *fergusoni* Hall, 1912 p. 228
 Fig. 2: No. 72811. Locality 1. x 2.5
 Fig. 3: No. 72810. Locality 1. x 2.75
- Figs. 4—7: *Isograptus caduceus* (Salter, 1853) var. *velata* Harris, 1933 . p. 232
 Fig. 4: No. 72831. Locality 1. x 3
 Fig. 5: No. 72828. Locality 2. x 3
 Fig. 6: No. 72823. Locality 1. x 3
 Fig. 7: No. 72824. Immature specimen.
 Locality 1. x 3
- Figs. 8—9: *Isograptus caduceus* (Salter, 1853) var. *divergens* Harris, 1933 p. 231
 Fig. 8: No. 72812. Locality 1. x 2.5
 Fig. 9: No. 72826. Locality 2. x 2.5
- Fig. 10: *Didymograptus extensus* (Hall, 1858) p. 229
 Small form. No. 72823. Locality 1. x 3
- Fig. 11: *Tetragraptus bigsbyi* (Hall, 1865) p. 233
 No. 72819. Locality 1. x 3
- Fig. 12: *Glossograptus hincksi* (Hopkinson, 1872) p. 234
 No. 72822. Locality 1. x 3
- Fig. 13: *Glossograptus hincksi* (Hopkinson, 1873) var. *fimbriatus*
 (Hopkinson, 1873) p. 235
 No. 72813. Locality 1. x 3
- Figs. 14—15: *Glyptograptus dentatus* (Brongniart, 1828) p. 233
 Fig. 14: No. 72827. Locality 2. x 3
 Fig. 15: No. 72810. Locality 1. x 3

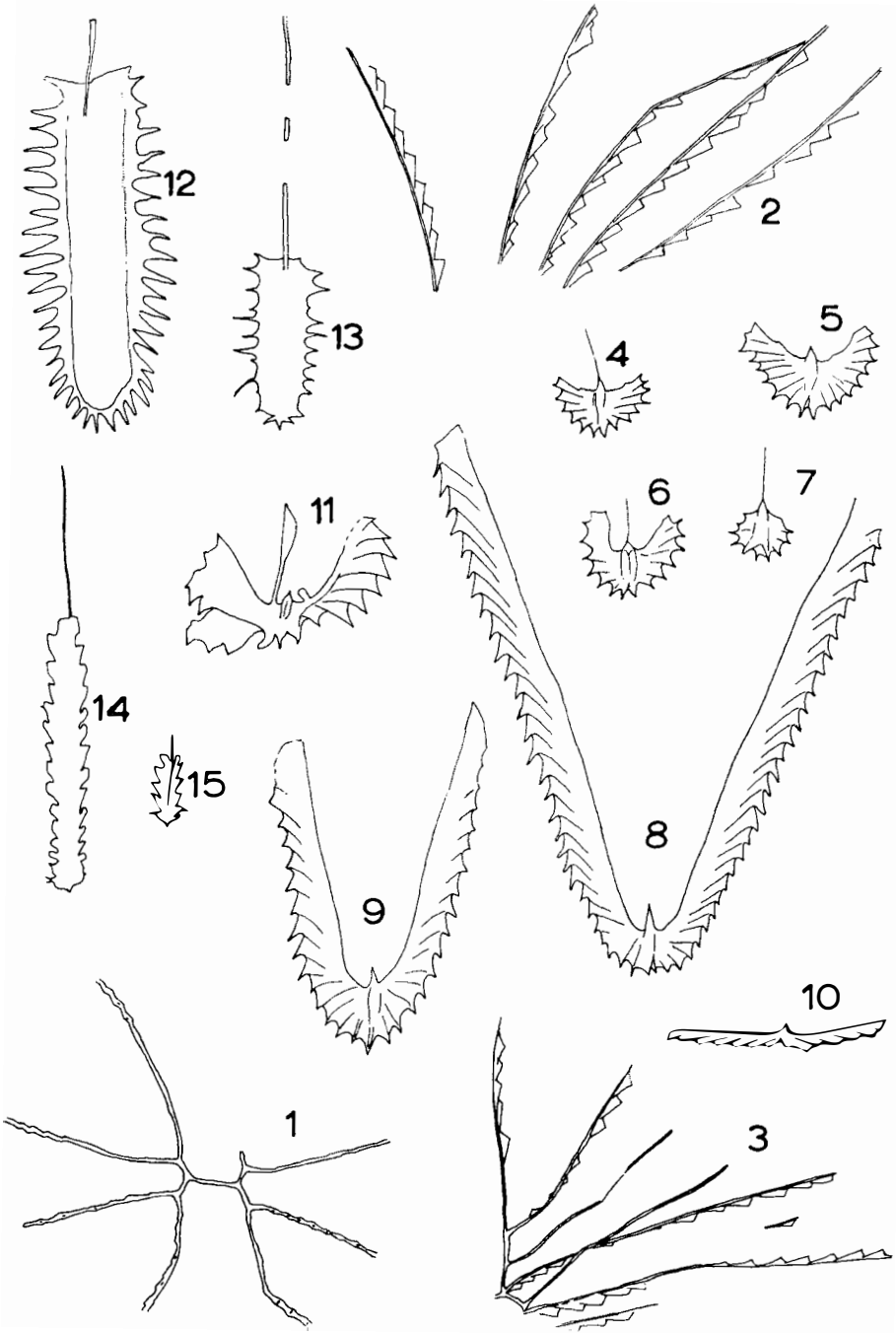
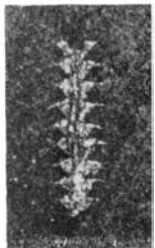
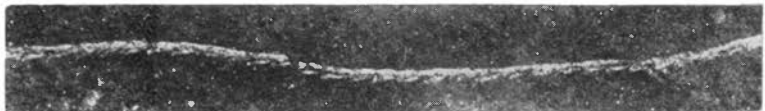
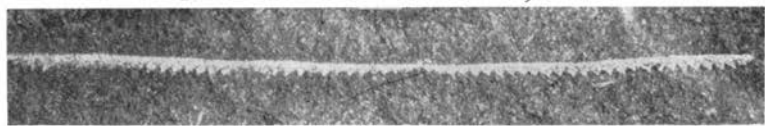
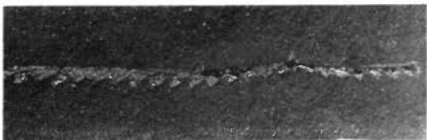
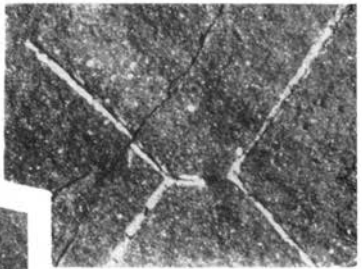
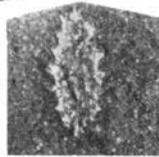
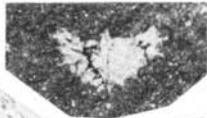
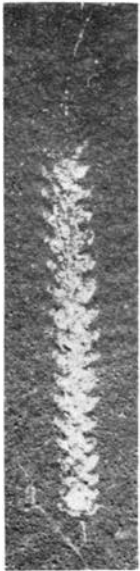
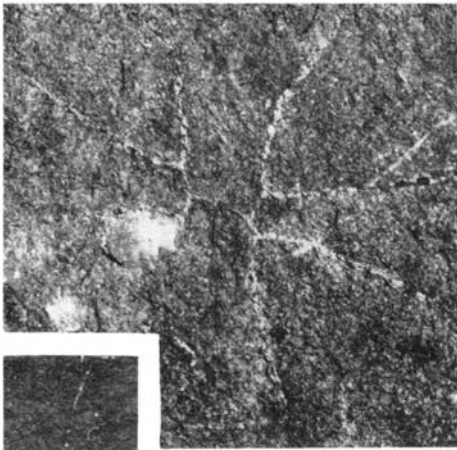


PLATE 2

The photographs are unretouched.

The specimens are from the Bogo Shale at the river Bogo in the Trondheim Region. They are deposited in the Paleontologisk Museum, Oslo, and the numbers given are their catalogue numbers.

Fig. 1: <i>Dichograptus octobrachiatus</i> (Hall, 1858) <i>minimus</i> n. subsp.	p. 227
Holotype (No. 72815). Locality 1. x 3.4	
Fig. 2: <i>Trichograptus</i> cf. <i>fergusoni</i> Hall, 1912	p. 228
(With a small specimen of <i>Glyptograptus dentatus</i> .) No. 72809. Locality 1. x 3.4	
Fig. 3: <i>Isograptus caduceus</i> (Salter, 1853) var. <i>velata</i> Harris, 1933	p. 232
No. 72820. Locality 1. x 3.7	
Fig. 4: <i>Tetragraptus quadribachiatus</i> (Hall, 1858)	p. 233
No. 72807. Locality 1. x 3.4	
Fig. 5: <i>Phyllograptus anna</i> Hall, 1865	p. 233
No. 72829. Locality 3. x 3.4	
Fig. 6: <i>Glyptograptus dentatus</i> (Brongniart, 1828)	p. 233
No. 72818. Locality 1. x 3.4	
Figs. 7—8: <i>Isograptus caduceus</i> (Salter, 1853) var. <i>divergens</i> Harris, 1933	p. 231
Fig. 7: No. 72830. Locality 2. x 1.8	
Fig. 8: No. 72825. Locality 1. x 1.8	
Fig. 9: <i>Glossograptus hincksi</i> (Hopkison, 1872)	p. 234
No. 72821. Locality 1. x 1.9	
Figs. 10—11: <i>Didymograptus extensus</i> (Hall, 1858)	p. 229
Fig. 10: No. 72814. Locality 1. x 2.5	
Fig. 11: No. 72817. Locality 1. x 1.8	
Fig. 12: <i>Didymograptus</i> cf. <i>leptograptoides</i> Monsen, 1937	p. 230
No. 72816. Locality 1. x 3.4	
Fig. 13: <i>Hallograptus inutilis</i> (Hall, 1865)	p. 234
No. 72809. Locality 1. x 3.4	



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